

Desalination Overview

What Are Our Options?



Arizona Water Initiative
Desalination Committee Meeting
September 20, 2016

Zacary Richards

Discussion Topics

Current & Potential Saline Water Projects

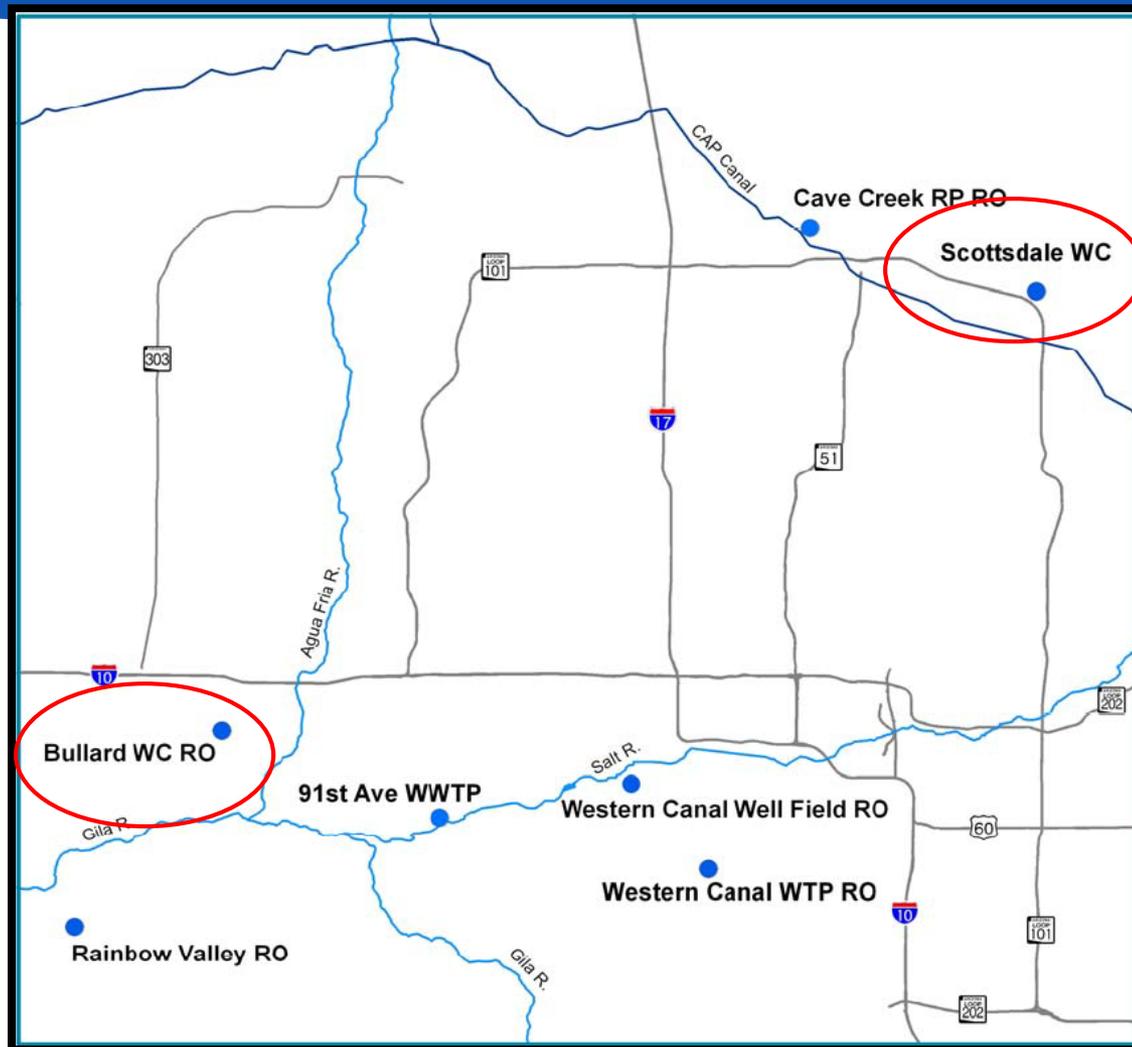


Current & Potential Ocean Water Projects



Current Saline Water Projects

What Has Been Done?

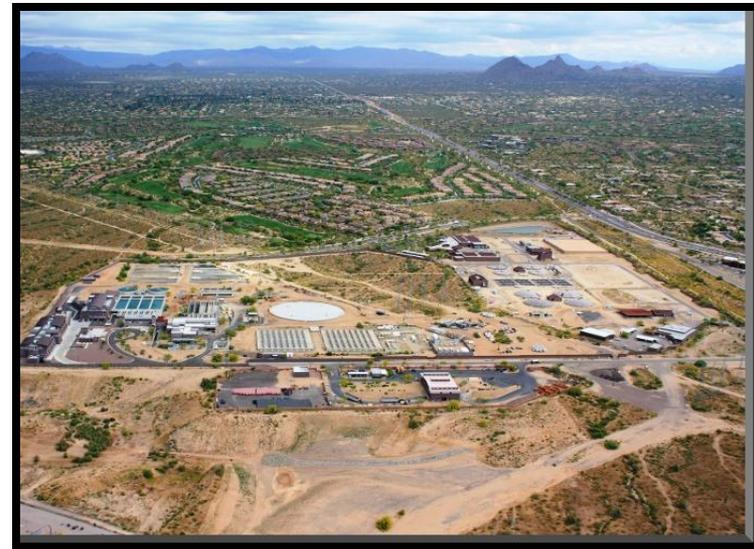


Current Saline Water Projects

What Has Been Done?

Scottsdale Water Campus Advanced Water Treatment Facility

- * Began production in 1999
- * The RO system capacity increased from 13.8 MGD to 20 MGD using a large-diameter (16 in.) RO system to save space.
- * 20 MGD of ultrapure recycled water for use in blending with CAP water and effluent for both groundwater recharge and golf course irrigation
- * Addresses contaminant removal, including N-nitrosodimethylamine (chlorination byproduct) and other unregulated compounds, using a combination of ozonation, chloramination, and ultraviolet (UV) technology.
- * Brine concentrate is discharged into the 91st Avenue Wastewater Treatment Plant



Current Saline Water Projects

What Has Been Done?

Goodyear Reverse Osmosis (RO) Facility

- * Centerra Well contains 1,900 mg/L of Total Dissolved Solvents (TDS) and 17.9 mg/L of Nitrate
- * 3.2 MGD of brackish water is sent from the well to the RO Facility
- * Facility treats 2.7 MG of well water and provides 2 mg of clean drinking water which is mixed with .5 MG of brackish water
- * The .7 MG of brine concentrate (7,447 mg/L TDS) is mixed with wastewater, cleaned to an A+ quality at the 157th Ave water reclamation plant, and stored underground
- * **Capital Cost:** \$1.98M
- * **Operating Cost:** \$0.93/kgal

Parameter	Value
Calcium, mg/L	163
Magnesium, mg/L	69
Sodium, mg/L	414
Sulfate, mg/L	505
Barium, mg/L	0.04
Nitrate, mg/L	17.9
Silt Density Index, units	1.2 – 5.6
Fluoride, mg/L	0.7
Temperature, degrees Fahrenheit	51.8
TDS, mg/L	1,940
Total Alkalinity (CaCO ₃), mg/L	193
pH, standard units	7.4
Arsenic, mg/L	0.003

*Data from City of Goodyear, 2004

Current Saline Water Projects

What Has Been Done?

Bullard Water Campus

- * A permanent facility to replace the emergency facility in Goodyear
- * Water capacity of approximately 5 MGD and began operation in early 2008
- * 15,500 square foot prefabricated building including:
 - * Eight RO skids
 - * Sulfuric acid chemical treatment system
 - * Threshold inhibitor system
 - * Caustic soda chemical treatment system
 - * Chlorine system
 - * Clean in place system
 - * Sewer discharge tank
 - * SCADA operating and monitoring system, and site enhancements

Capital Cost: \$10,789,745

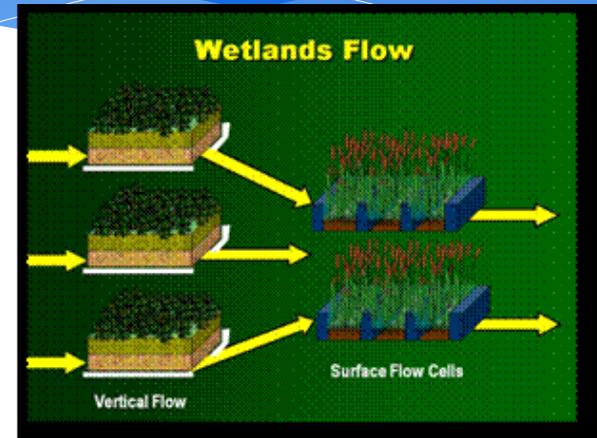


Current Saline Water Projects

What Has Been Done?

Bullard Water Campus

- * Wetlands brine treatment would reduce the volume of salt entering the 157th Ave water reclamation facility.
- * This will lower the salt content in reclaimed water. More landscaped facilities may be willing to use reclaimed water with lower salt content.
- * Lower salt content would reduce facility operating costs through improved efficiency.
- * Wetlands brine treatment will save energy.
- * Wetlands brine treatment would require less energy than other disposal alternatives for brine.



Methods of Brine Disposal

Cost of 10 MGD Concentrate Management (millions of dollars)						
10 MGD	Regulating Wetlands	Yuma pipeline	Injection wells*	Soften/2 nd RO/VSEP/EP	Evaporation ponds (EP)	Brine concentrator/EP
Capital	\$150.22	\$266.11	\$114.46	\$286.56	\$651.69	\$ 272.71
O&M	\$1.75	\$0.62	\$11.31	\$6.9	\$3.5	\$29.75
Annualized (50 years)	\$10.37	\$14.92	\$17.46	\$22.30	\$40.26	\$44.40

* No known site in central Arizona that meets criteria for concentrate injection.
 Note. Adapted from Poulson, 2010.

Location	2010		2020		2035	
	Size Plant	Concentrate	Size Plant	Concentrate	Size Plant	Concentrate
Bullard Water Campus	3.50	0.53	4.00	0.60	4.00	0.60
Scottsdale Water Campus	24.00	3.60	24.00	3.60	24.00	3.60
Cave Creek RP	0.00	0.00	13.00	1.95	20.00	3.00
Rainbow Valley RO	0.00	0.00	5.00	0.75	60.00	9.00
Western Canal Well Field	0.00	0.00	6.00	0.90	6.00	0.90
Western Canal WTF	0.00	0.00	0.00	0.00	60.00	9.00
Water Market (91st WWTP)	0.00	0.00	0.00	0.00	30.00	4.50
		4.13		7.80		30.60

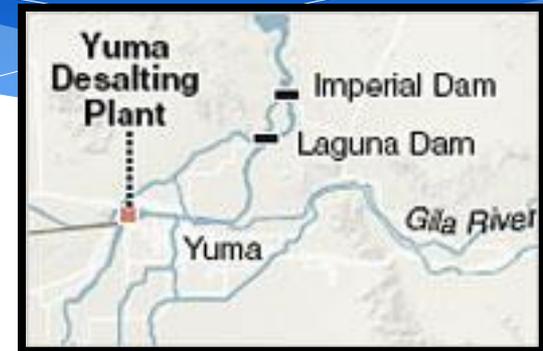
*million gallons per day

Current Saline Water Projects

What Has Been Done?

Yuma Desalting Plant (YDP)

- * Completed in 1992 to treat saline agricultural drainage from the Wellton-Mohawk Irrigation District until it became dormant
- * Bureau of Reclamation conducted a year-long pilot test from May 2010 to March 2011 and treated 30,496 acre-feet of drainage water (~27.2 MGD) at 1/3 of the plant's capacity
- * Power Consumption: 37,541 MWh with an average price of \$32.68 per MWh
- * 82% efficiency if operated at 430 psi, but higher power costs
- * Produced water had an average salt concentration of 252 mg/L TDS



Current Saline Water Projects

What Has Been Done?

Yuma Desalting Plant (YDP)

Trial Costs

Cost Element	Budget	Actual	Difference
Reclamation labor	\$ 3,411,492	\$ 1,502,568	\$ 1,908,924
Contract labor and services	\$ 2,662,752	\$ 2,656,869	\$ 5,883
Power	\$ 3,304,516	\$ 1,396,904	\$ 1,907,612
Chemicals	\$ 6,415,610	\$ 3,645,652	\$ 2,769,958
Materials, supplies, and parts	\$ 349,200	\$ 614,641	(\$ 265,441)
Contingency	\$ 414,500	\$ 404,496	\$ 10,004
Total	\$ 16,558,070	\$ 10,221,130	\$ 6,336,940

*lower than expected costs for power, labor, chemicals and materials

Final Pilot Run Report
Reclamation, 2012

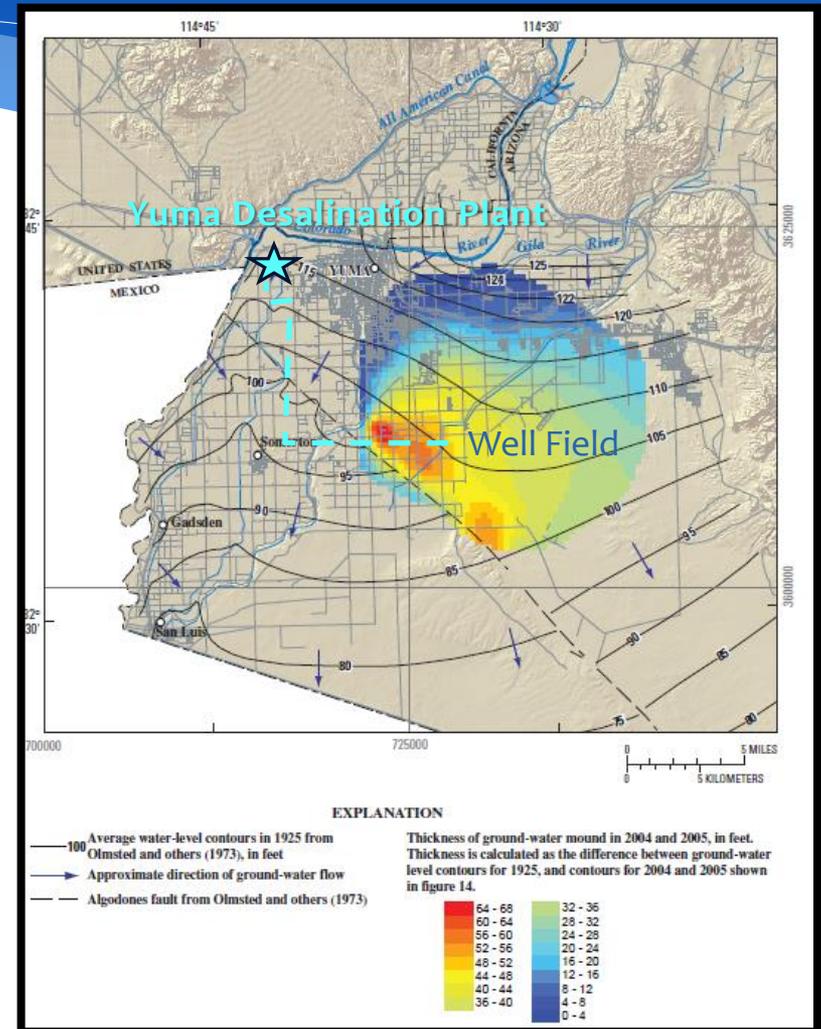
One time project	Capacity of Operations			Amortization period
	One third	Two thirds	Full	
	31,361 AFY	67,202 AFY	91,153 AFY	
Pilot Run Outcome				
Liquid ferric sulfate system	920,000			20
Sodium bisulfite system	250,000			20
MODE 1 diversion facility	1,000,000			45
Design Deficiencies				
Chlorine system	2,000,000			30
Reverse osmosis pumps	2,000,000	2,000,000	2,000,000	20
Ammonia system	1,650,000			20
Control block valves/actuators	590,000	590,000		20
Solids contact reactor		420,000		15
Reverse osmosis membranes	4,000,000	4,000,000	4,000,000	5
High pressure piping*	7,000,000	6,000,000	5,000,000	40
Railroad spur		5,000,000		50
Other repairs				
Media filter effluent piping	700,000			15
Media filter valves	680,000			20
Grit handling	340,000			20
Plant instrumentation	850,000	850,000	850,000	10
DCS strategies	200,000	100,000	50,000	10
Routine start-up activities	900,000	700,000	500,000	10
	\$52 per AF	\$45 per AF	\$46 per AF	
Totals	23,080,000	19,660,000	12,400,000	

Future Saline Water Projects

What Can We Do?

Yuma Brackish Groundwater Treatment of Yuma Mesa

- * USGS estimates 600,000 to 800,000 acre-feet of brackish groundwater
- * Estimated yield: 40,000 AFY
- * Capital Cost: \$132M
- * Annual O&M: \$1.7M
- * Implementation: 7-9 yrs



Future Saline Water Projects

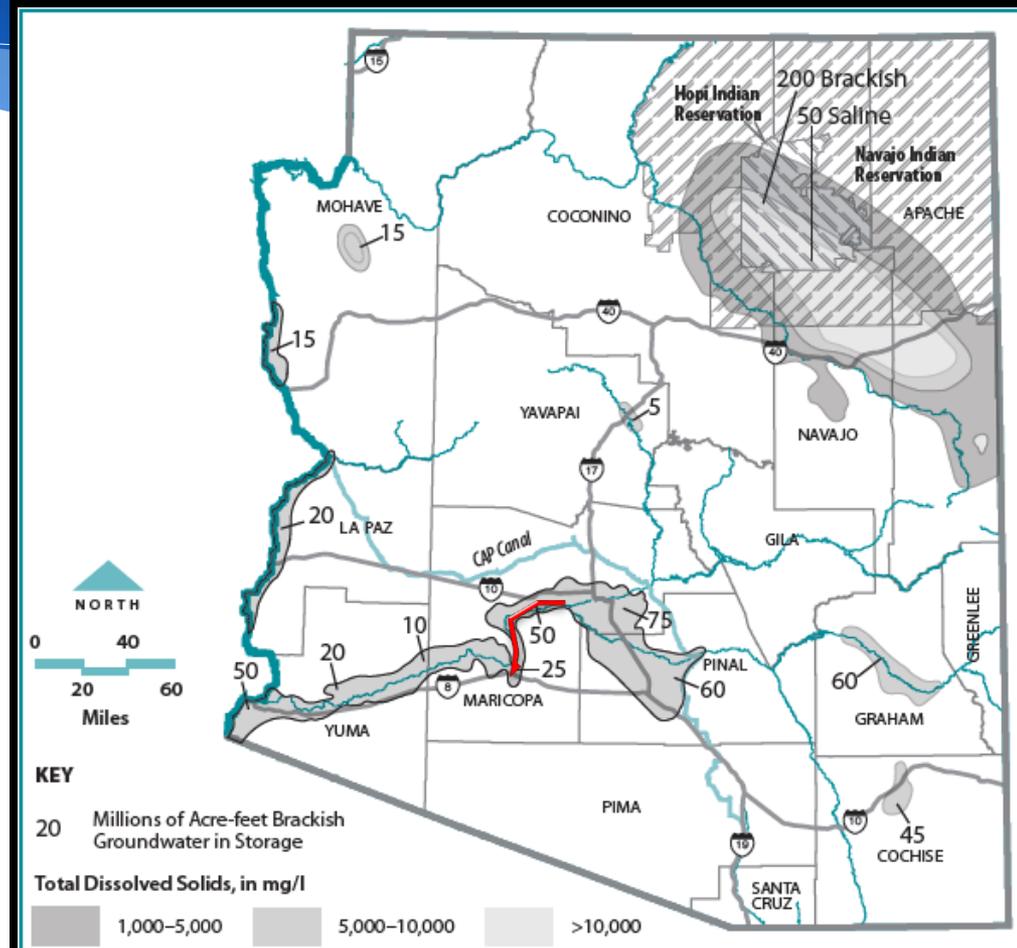
What Can We Do?

Navajo/Hopi Planning Area

- ❖ Saline groundwater due to bedded salt in sedimentary formations
- ❖ Little Colorado and Eight Lakes in the PA have impaired water quality due to levels of turbidity, lead, copper, mercury and silver in excess of use standards
- ❖ Municipalities are projected to consume 23,093 acre feet per year by 2035

Phoenix AMA Basin

- ❖ A 35 mile long brackish water supply exists on the Gila River between its confluence with the Salt River to the outfall of the Basin at Gillispie Dam

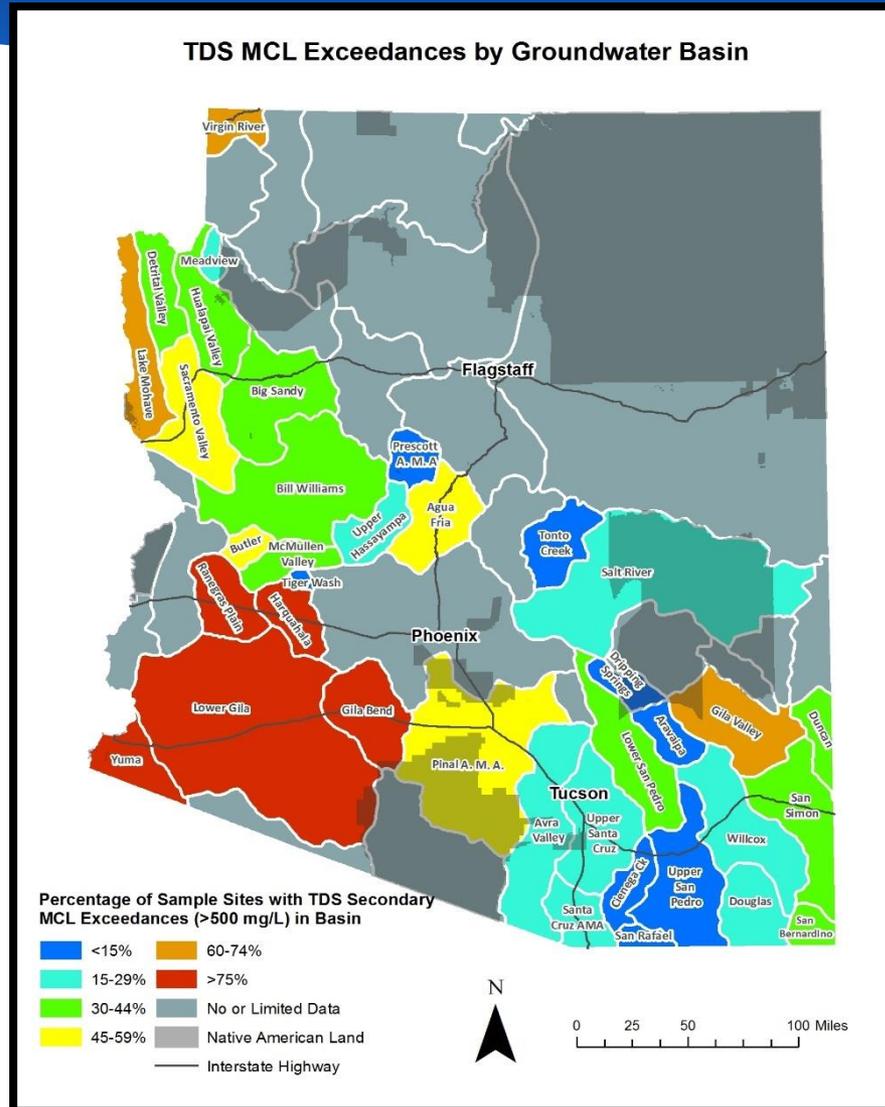


Source: Montgomery and Associates.

Sources of brackish groundwater in Arizona have been identified along the Colorado, Salt, and Gila rivers, associated with agricultural drainage, and elsewhere, associated with geological salt formations.

Future Saline Water Projects

What Can We Do?



Future Saline Water Projects

What Can We Do?

Desalination in California

Imperial Valley Drain Water Treatment

- * Yield = 200,000 AFY increments
- * Capital Cost = \$2.25B
- * Annual O&M = \$77M
- * Unit Cost = \$1,000/AF
- * Implementation = ~ 15 years

Coachella Valley Drain Water Treatment

- * Yield = 101,000 AFY
- * Capital Cost = \$395M
- * Annual O&M = \$30M
- * Unit Cost = \$500/AF
- * Implementation = ~15 years

Key Factors:

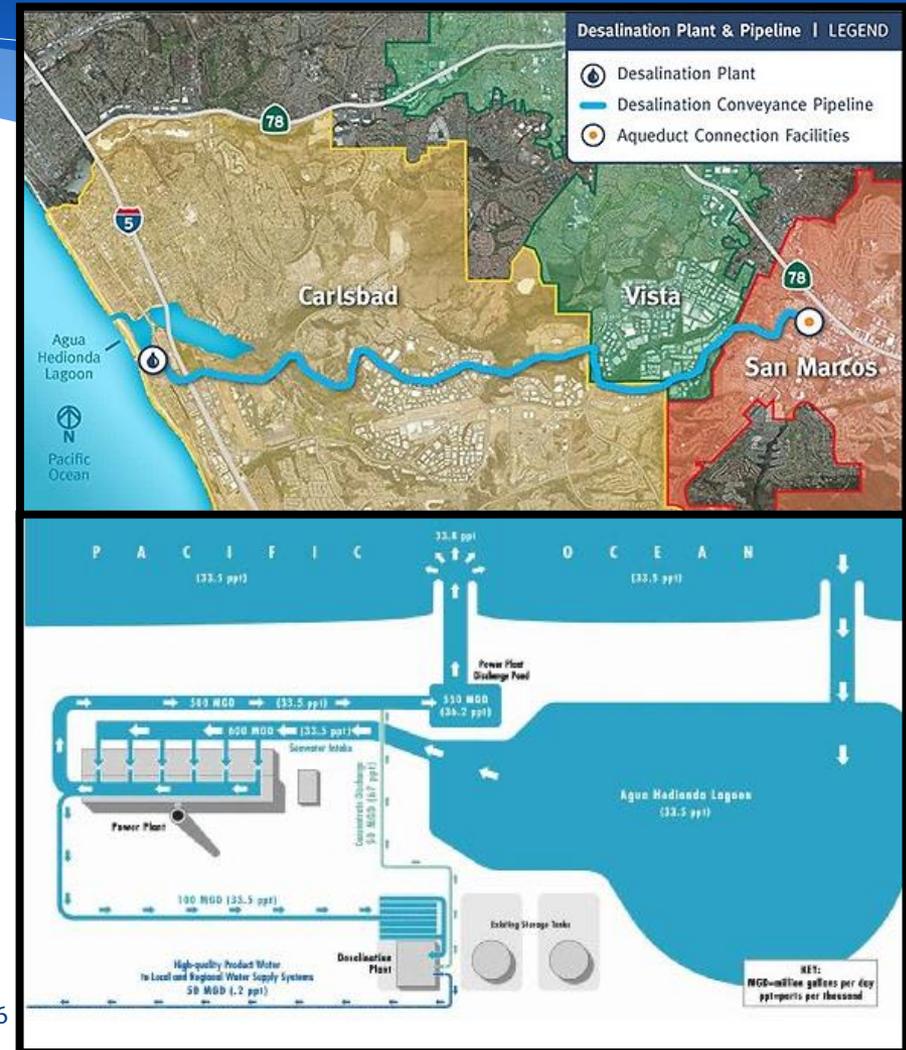
- Dust Control
- Reduced Flows to Salton Sea
- Migratory Bird Impacts

Current Ocean Water Projects

What Has Been Done?

Carlsbad Desalination Plant

- ❖ 2,000 pressure vessels with 8 RO membranes in each vessel
- ❖ Draws 100 MGD of ocean water and produces 50 MGD or 7% of San Diego's water supply (enough for 112,000 households)
- ❖ Two stage pretreatment process
 - ❖ Microfiltration
 - ❖ Multimedia Filtration Tanks
- ❖ **Energy recovery devices recycle 46% of energy used** in the RO process saving \$12m annually
- ❖ **40MW to operate** which is energy for 30,000 homes and costs \$49m-\$59m annually
- ❖ \$2000 - \$2200 per acre foot or an increase of \$5 - \$7 on monthly water bills
- ❖ **Capital Cost: \$734m** in private bonds
- ❖ **15 year process**

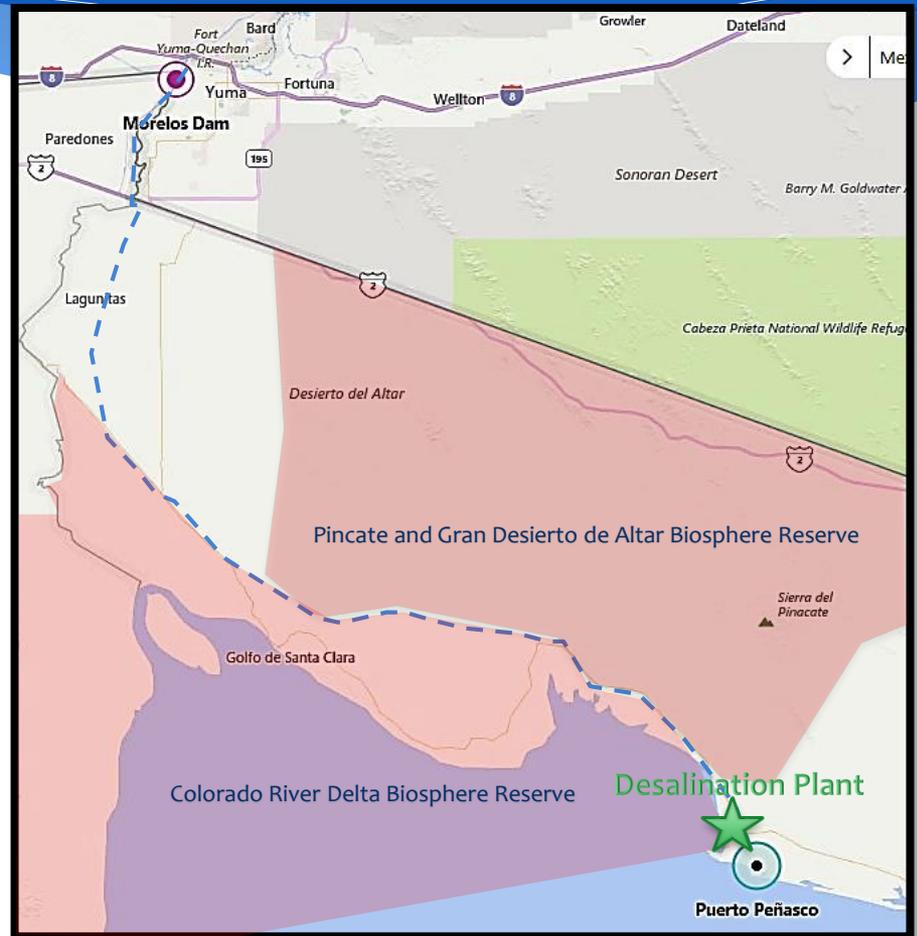


Future Ocean Water Projects

What Can We Do?

Sea of Cortez Desalination

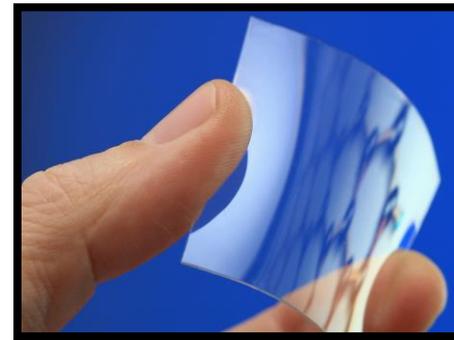
- * Treated water could be conveyed via pipeline and discharged upstream of Morelos Dam
- * RO rejected brine would be deposited into the Sea of Cortez
- * Water could be delivered to Mexico in exchange for upstream storage or diversion
- * Estimated Yield: 200,000 to 1.3M AFY
- * Capital Cost: \$4.5B
- * Annual O&M: \$185M
- * Unit Cost: \$2,200/AF
- * Implementation: 15 yrs



Things to Consider

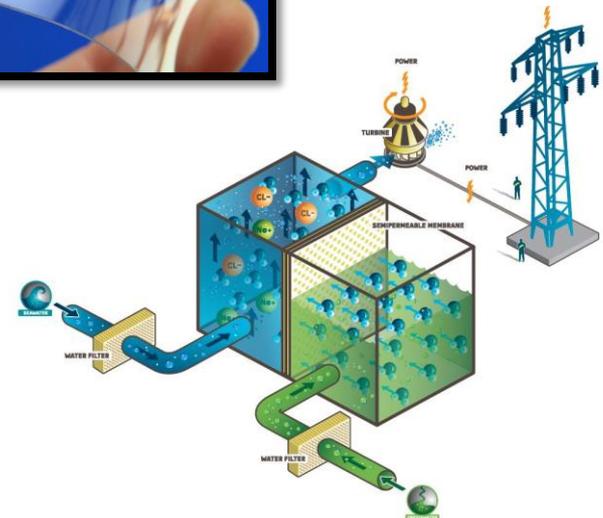
Membrane Upgrades

- ❖ Reducing energy costs by using graphene, which is one atom thick, instead of polyamide
- ❖ Use 16 inch diameter membranes instead of 8 inch diameter – more surface area and less energy cost, however, only one manufacturer makes them



Dilution Solution

- ❖ Using reverse osmosis pressure retarded osmosis (RO-PRO) results in a decrease in energy by 30%



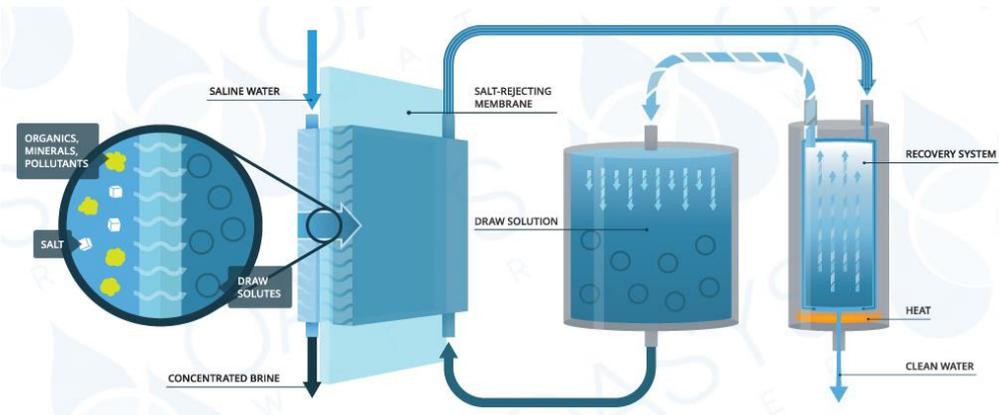
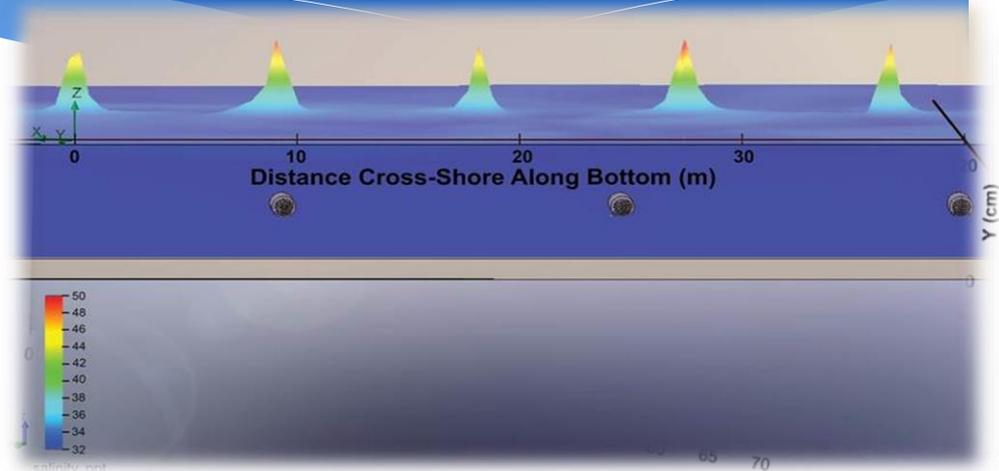
Things to Consider

Recapturing and Renewable

- ❖ Turbochargers take kinetic energy from the output and reapply it to the input
- ❖ Pretreating water before it goes into the membranes saves energy and the life of the membranes

Environmental Concerns

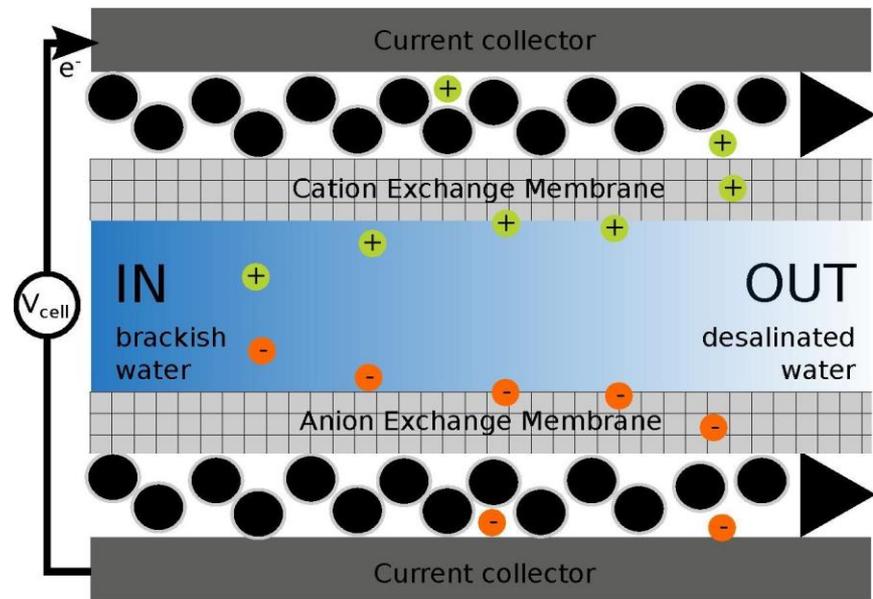
- ❖ RO-PRO reduces salt concentration in the discharge
- ❖ Forward osmosis in smaller plants that produce no more than 26,000 gallons of water a day see a 42% reduction in energy use
- ❖ Diffusers increase the volume of seawater mixing with the concentrated discharge and prevents spots on the ocean floor containing high salt levels



Things to Consider

Membrane Capacitive Deionization (MCDI)

- * Separates ions using electrodes
- * 318,000 gallons per day plant in China
 - * 75% water recovery rate
 - * 1kWh for 264 gallons = \$0.22



Questions?

Arizona Water Initiative



Coordinator:

Zacary Richards
zbrichards@azwater.gov
(602) 771-8311